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Abundance and Run Timing of Adult Salmon in Tanada Creek in the Wrangell-St. Elias National Park and Preserve

Annual Report No. FIS00-01-3

Eric R. Veach

Wrangell - St. Elias National Park and Preserve
P.O. Box 439
Mile 106.8 Richardson Hwy.
Copper Center, Alaska 99573

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ANNUAL REPORT SUMMARY PAGE

Title: Abundance and Run Timing of Adult Salmon in Tanada Creek in the Wrangell-St. Elias National Park and Preserve

Study Number: FIS00-01-3

Investigators/Affiliations: Eric R. Veach Wrangell - St. Elias National Park and Preserve (WRST)

Management Regions: Cook Inlet/Gulf of Alaska

Information Type: Fish stock status and trends

Issues Addressed: Tanada Creek salmon are highly susceptible to Federal and state subsistence users as well as commercial harvest. The Batzulnetas Area subsistence fisheries specifically target Tanada Creek salmon stocks. Monitoring Tanada Creek salmon stocks aids in assessing sockeye salmon escapement into the uppermost tributaries of the Copper River and in evaluating the harvest opportunity for subsistence fishers in the Batzulnetas Area fishery and the uppermost portion of the Glennallen Subdistrict. The dynamic nature of the flows in Tanada Creek has prevented a rigid picket weir from functioning successfully. The feasibility of a floating resistance board weir and a video counting tower as monitoring tools are tested in Tanada Creek.

Study Cost: **$**138,000

Study Duration: May 2000 to September 2002

Key Words: Batzulnetas, Copper River, Sockeye, Tanada Creek, Tanada Lake Stock/status and Trends, Use

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INTRODUCTION

The Upper Copper River drainage provides spawning habitat for sockeye *Oncorhynchus nerka*, chinook salmon *O. tshawytscha*. Significant numbers of adult salmon are harvested in commercial drift gillnet operations near the mouth of the Copper River from mid-May to September. Salmon escapement into the Upper Copper River system contributes to Federal and State subsistence fishing through September 30. The monitoring and evaluation of these runs is essential to ensure that Wrangell - St. Elias National Park and Preserve (WRST) maintains natural and healthy populations as required by the Alaska National Interest Lands Conservation Act (ANILCA).

The Copper River system supports over 124 known stocks of sockeye salmon of which at least 12 occur above the confluence of the Copper and Slana Rivers (Roberson 1987). Two of these stocks migrate through Tanada Creek and spawn along the shores of Tanada Lake or in the lake outlet (Figure 1). Chinook salmon are believed to be present in incidental numbers in Tanada Creek (Raeder 1997, Raeder and others 1998).

Tanada Creek sockeye are one of the uppermost runs of sockeye on the Copper River and support a subsistence salmon fishery both in the Copper River and in Tanada Creek. Two native villages harvest salmon in the Batzulnetas Area fishery. Batzulnetas, the Ahtna name for the traditional fishing site on Tanada Creek, has been used by the Ahtna people for over 1000 years (Kari 1986). The Batzulnetas fishery was in litigation from 1985 –2000 as Katie John and others attempted to reestablish their traditional subsistence fishery. The “Katie John Decision” resulted in the expansion of Federal management of fisheries in waters under Federal jurisdiction throughout Alaska.

OBJECTIVES

Specific objectives for this study in FY 2002 are:

1. acquire data addressing annual variation of abundance of salmon populations in Tanada Creek;
2. determine the variation of timing of salmon runs in Tanada Creek;
3. provide a relative index of abundance using aerial observations and assess that index against actual weir counts;
4. provide a hands-on educational opportunity for local students to learn about the Tanada Creek salmon run and how it is managed; and
5. determine the feasibility of a video escapement recorder system as a long term method of estimating salmon escapement in Tanada Creek.

METHODS

Study Area

Watershed Description

Tanada Creek is a third order perennial stream and a tributary to the Upper Copper River in southeast interior Alaska (Figure 1). The stream flows through the Copper River Plateau and encompasses a watershed area of approximately 550 km^2. Originating at Tanada Lake (62°27'N, 143°23'W), Tanada Creek runs 30 km northwest to its confluence with the Copper River (62°37'N, 143°48'W). The terrain is nearly level to gently rolling throughout the creek basin and the stream gradient is less than 2%. The vegetation is dominated by mosses, sedges, dwarf birch and willows. Black and white spruce are the primary evergreens, with stands of cottonwoods interspersed. The soils are poorly drained and are underlain by shallow permafrost (USDA 1979).

Annual precipitation in the area averages 39 cm and ambient temperature ranges from a high of 32° C to a low of - 46° C. Average annual temperature is - 2.5° C (NOAA 1995). Breakup normally occurs in May, and water bodies freeze in September or October.

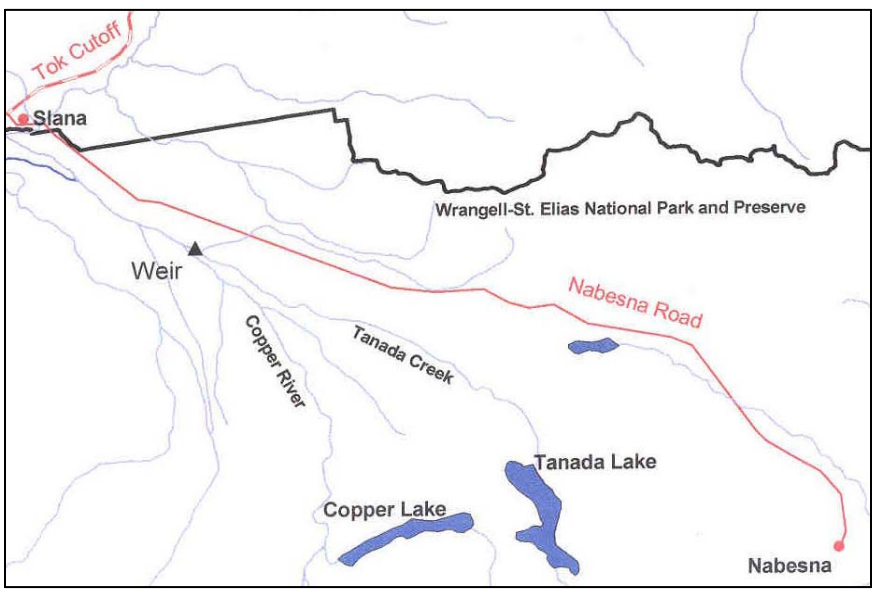

Figure 1. Tanada creek and vicinity.

Weir Site Description

The weir site was located 920 m upstream from the Copper River and approximately 160 m downstream from the Batzulnetas village site (Figure 2). Stream width is about 9 m. The vertical banks are approximately 0.7 to 1.0 m high and bank undercutting ranges between 0 to .5 m. Maximum water depth at midstream during bank-full conditions is estimated at 1.2 m. Channel substrate is predominately cobble, with interstitial sand and gravel. The stream banks are stabilized by spruce, willow, alder and an understory of moss and horsetail ferns. Spruce and cottonwoods contribute to stream shading.

A permanent cross section was established on June 9, 1998 about 10 m upstream of the weir. Four brass cap reference markers were set along the transect. A staff-gage was placed in the stream near the north bank intersecting the cross section.

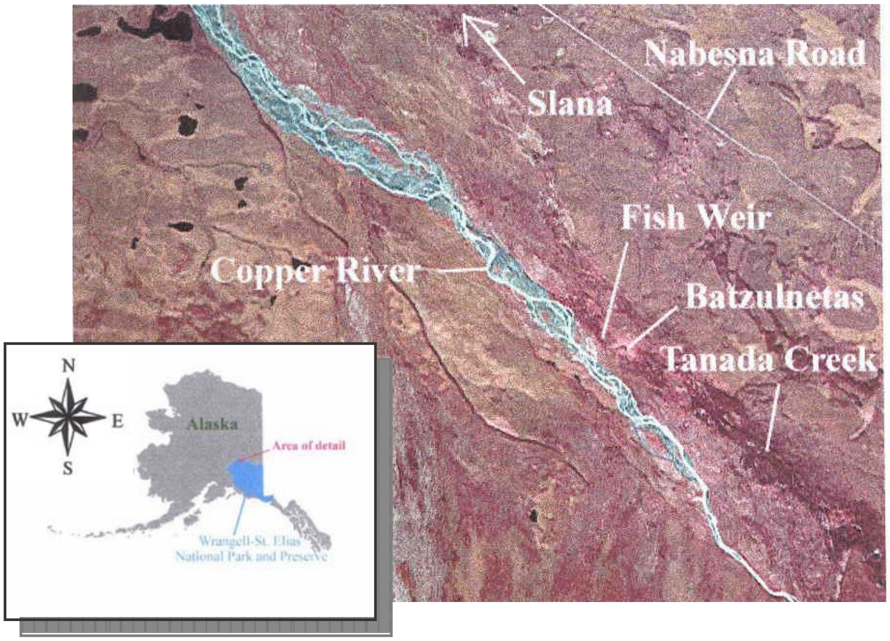

Figure 2 Location of Tanada Creek Fish Weir, 2002

Weir Installation and Operation

The floating resistance board weir was installed as described by Tobin (1994) with the exception that the hooks attaching the weir panels to the cable were installed upside down. This unfortunate oversight was not discovered until after the run ended. This resulted in a gap between the substrate rail and the angle iron forming the base of the weir panels larger than 3.75 cm. While the cause of the gap was not determined during the run, the gap was observed and we attempted to correct this by covering the gap with sand bags. The weir with picket spacing of 3.75 cm was placed at the end of a straight 120 m section of stream with moderate water velocity and laminar flow. When resistance boards were in the "up" position the downstream end of the weir lay flat on the waters surface. When resistance boards were in the "down position", the downstream end of the weir was raised approximately 75 cm above the surface of the water (Figure 3). A box, 1 m x 3 m, was constructed of 2x4 lumber, aluminum channel and cyclone fencing. Gates that could be raised and lowered were installed at either end to allow for holding, sampling, and releasing fish. The box was placed on the north bank side of the weir. The weir was operational on June 27, 2002. Two shifts monitored the weir for fish passage from June 27 to August 15. The weir was staffed 7 days per week with 2 shifts daily. A staff gauge and water temperature reading was taken at the beginning of each shift. The staff gauge was replaced due to overwinter damage to the previous gauge. Gates on the box were closed when the weir was not monitored. The number of salmon counted was recorded hourly.

2 *HOBO® TEMP* data loggers were placed in submersible cases at the base of the staff gauge to collect water temperature data throughout the summer. The data loggers recorded temperatures every 15 minutes. Water temperatures were also measured daily from a thermometer hanging on the outside of the sampling box. The measurements of the 2 Hobo temperature recorders were averaged and the resulting average temperature readings were again averaged for the entire day to determine average daily temperature.

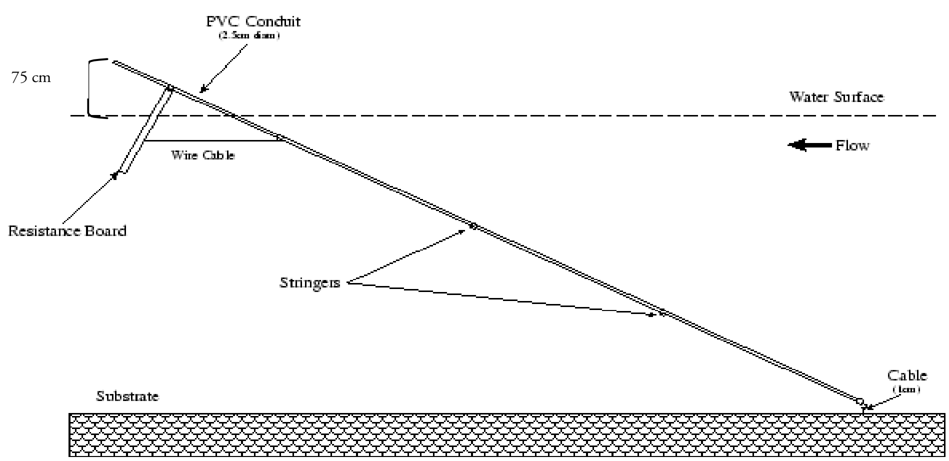

Figure 3. Placement of resistance boards in "down" position

Biological Data

Sockeye and chinook salmon were sampled for scales and sexed using external characteristics. Two measurements were taken on each fish, from mid-eye to fork length (MEF) and mid-eye to posterior insertion of anal fin (anal). Lengths were recorded to the nearest millimeter. A tagging cradle was used to facilitate handling. Scales were collected from the preferred area, located on the left side of the fish and two rows above the lateral line on a diagonal from the posterior insertion of the dorsal fin to the anterior insertion of the anal fin, according to Alaska Department of Fish and Game (ADFG) sampling protocol. One scale was taken from each sockeye salmon in accordance with this protocol. One scale is typically sampled from sockeye salmon while multiple scales would typically be sampled from chinook salmon (Steve Moffitt, personal communication). Sampled fish were marked with a left opercle punch. Scale samples were analyzed by the ADFG Commercial Fisheries Division in Cordova. Ages were adjusted for resorbed margins based on length frequency cut-points.

Sockeye salmon were beach seined and examined for opercle marks in Tanada Lake, the outlet of Tanada Lake and Tanada Creek slightly downstream of the outlet in late summer. Four recapture events were performed and live fish and carcasses were examined. Examined fish were marked with a unique mark. The results of the beach seining were analyzed using Stratified Population Analysis System (SPAS) software to generate a pooled Petersen estimate (Seber, 1982).

Otoliths were not collected in 2002 because we had been unsuccessful in finding anyone to process otoliths collected in 2001.

Video Escapement Operation

On June 27, 2002, a video escapement recorder was installed 15 m downstream from the weir. A 1.5 in diameter pipe 15 m long was affixed horizontally between two spruce trees on either side of the creek. A 3 mm cable was attached to the trees above the pipe and was looped through guides along the pipe to provide extra support. Two remote cameras, sealed in waterproof housings were suspended from the pipe above the water surface approximately 5.5 m. The cameras were equipped with a 3.5 mm ultra-wide angle lens to allow for field of view up to 4 m. A waterproof case containing a time-lapse frame recording system and multilplexer unit was housed on the north bank of the creek. Two 12-volt deep cycle batteries provided power to the system. An immersible water turbine served to provided power to the system and keep the batteries charged. A high contrast substrate panel was fixed to the streambed below the overhead cameras (Oatis and Dickson 2001). A row of pickets 2 m long was placed in the streambed perpendicular to the panel. The pickets, which bisected the creek at approximately 4.8 m from each bank, served two purposes; (1) to delineate the midstream field of view of the two cameras, providing a defined edge for the mid stream frame of the video; (2) to prevent salmon from moving between one camera view and the other while swimming upstream.

The time-lapse recorder was programmed to capture one image every .14 seconds allowing for up to 64 hours of video to be collected on a single T-160 tape. Tapes were changed every 48 hours. A viewing station was set up at the local ranger station in Slana to review the tapes.

RESULTS

Weir Operation

The weir was operated from June 27-August 15, 2002. High water and heavy debris flows submerged the weir and interrupted counting for 1 day (July 30). Two depth readings were recorded daily, an average was calculated when different depths were recorded in a 24-hour period (Figure 3). Water depth at the staff gauge ranged from 1.45 feet to >4 feet (flood stage), with a mean depth of 2 feet. Tanada Creek was at flood stage July 30, at which point the weir was completely submerged and water channeled through the wooded area on the north bank of the creek. The weir sustained only minor damage and was operational again July 31. Some fish leakage was observed during operation of the weir and due to the late start date and some problems with high flows, some fish leakage did occur.

Recorded water temperatures during weir operations ranged from 45 to 65 degrees F, with a mean temperature of 55 degrees F. The coolest temperature was recorded on June 26, and the warmest temperature was recorded during the day on July 23.

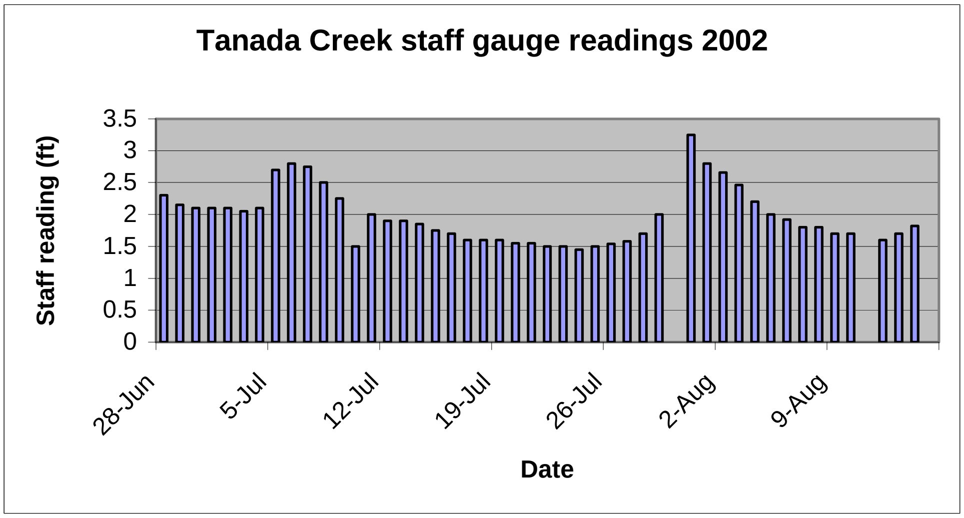

Figure 4. Staff gauge readings at the weir during 2002.

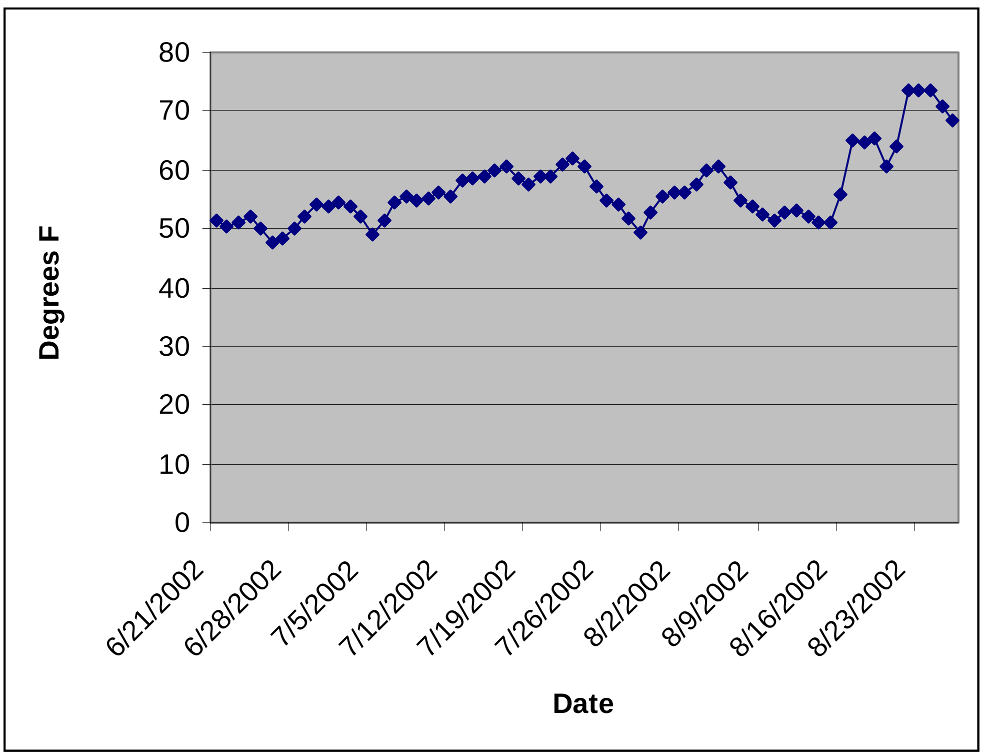

Figure 5. Average daily water temperature in Tanada Creek at the weir site.

Biological Data

Total sockeye *Oncorhynchus nerka* observed at the weir between June 28-August 10 totaled 2489 (Table 1). Five chinook salmon were counted between July 4 and July 8. A total of 675 sockeye were sampled for length and sex information. Average mid-eye to fork (MEF) length for males was 593 mm with a standard error of 25.7. Females averaged 634 mm in length with a standard error of 26.5. Females comprised 26.5 % of the sample (Table 2). The majority (88%) of the population was composed of age 1.3 fish (Table 3). The age composition of the population did not substantially change during the run (Table 4).

Year	Weir	Aerial	***Year***	Weir	Aerial	***Year***	Weir	Aerial
1962	—	1500	***1975***	128	700	***1989***	—	3300
1963	—	1060	***1976***	—	2200	***1990***	—	3000
1964	—	1500	***1977***	—	2800	***1991***	—	3050
1965	—	3300	***1978***	2265	2625	***1992***	—	3450
1966	—	10	***1979***	10244	5225	***1993***	—	—
1967	—	1	***1980***	—	13700	***1994***	—	—
1968	—	150	***1981***	—	11200	***1995***	—	—
1969	—	6	***1982***	—	11680	***1996***	—	—
1970	—	1000	***1983***	—	10900	***1997***	27521	7875
1971	—	3843	***1984***	—	16100	***1998***	28992	4470
1972	—	480	***1985***	—	11700	***1999***	—	—
1973	—	10	***1986***	—	8260	***2000***	—	4500
1974	—	2800	***1987***	—	8350	***2001***	1660	400
			1988	—	3825	***2002***	6186*	1950

* Estimate based upon mark-recapture sampling actual weir estimate 2489

Table 1. Comparison of weir and aerial counts of salmon in Tanada Creek and Tanada Lake.

	Avg. length MEF mm	***Range***	***n =***
sockeye			
females	593 (25.7)	500 - 690	179
males	634 (26.5)	540 - 750	496

Table 2. Average lengths of sampled sockeye salmon in 2002.

Age (n=554)	0.3	1.2	1.3	1.4	2.3
Male	0.2%	5.8%	91.0%	0.2%	2.7%
Female	0.7%	17.7%	79.4%	0.0%	2.1%
Total	0.4%	8.8%	88.1%	0.2%	2.5%

Table 3. Proportion of age in sample by sex for entire population.

Period	0.3	1.2	1.3	1.4	2.3	Sample Size
6/29-7/19	0.31%	5.92%	90.34%	0.31%	3.12%	321
7/20-7/29	0.60%	9.52%	88.10%	0.00%	1.79%	168
7/30-8/10	0.00%	21.54%	76.92%	0.00%	1.54%	65
						554

Table 4. Proportion of age in sample by period.

The highest daily estimate occurred on July 6, when 392 salmon passed through the weir (Figure 5). The median run date occurred July 12 after 1245 fish passed through the weir. From July 15 to August 15, there were only two days when daily counts exceeded 100 salmon. From August 7^{th} to August 15, three sockeye were counted through the weir (Figure 5).

Abundance of sockeye salmon that escaped to Tanada Lake during the sampling period was estimated using the mark and two-event recapture histories of fish according to the Schnabel model. This estimate was 6,186 with a standard error of 537. The estimate was based on a sample size of 702 live and dead sockeye salmon (Table 5). Modeling and analysis of the mark and recapture sample data was done by Karen Hyer, FIS and OSM (See Appendix B).

Modeling Analysis

Recaptures from the first two sampling events were pooled to calculate the first recapture event. If a salmon was recaptured more than once during the two-day event, additional recaptures were noted on the datasheet but were not used in the abundance calculation. Recaptures from the third and fourth sampling event were pooled to calculate the second recapture event. Again, salmon recaptured more than once during the second two-day event were noted on the datasheet, but additional recaptures were not used in the abundance estimate.

The Schnabel model allows for time variation in capture probabilities. The assumptions necessary for a reliable estimation of abundance are:

1.) all salmon have a constant probability of capture within a sampling event;
2.) the population remains constant with no recruitment and mortality during the sampling event; and,
3.) marked fish do not lose their marks.

Assumption one was tested by fitting two models. First, a model assuming heterogeneous capture probabilities within a sampling event was fit to the data. A second model assuming constant capture probabilities was then fit to the data. The most parsimonious model was chosen as the correct model. To meet the second assumption recapture sampling was started 13 days after the last salmon was marked at the weir. The 13 day time period allow all the fish to migrate into the lake. Finally, batch marks were given to the fish eliminating the need for external tags and potential for tag loss. The majority of fish sampled (93%) were alive, and marks did not deteriorate as they might on decomposed carcasses.

The computer program MARK was used to generate the estimate.

The estimate of the total sockeye salmon in Tanada Lake using mark-recapture techniques was 6,186 (95% CI=5243, 7358; SE=537).

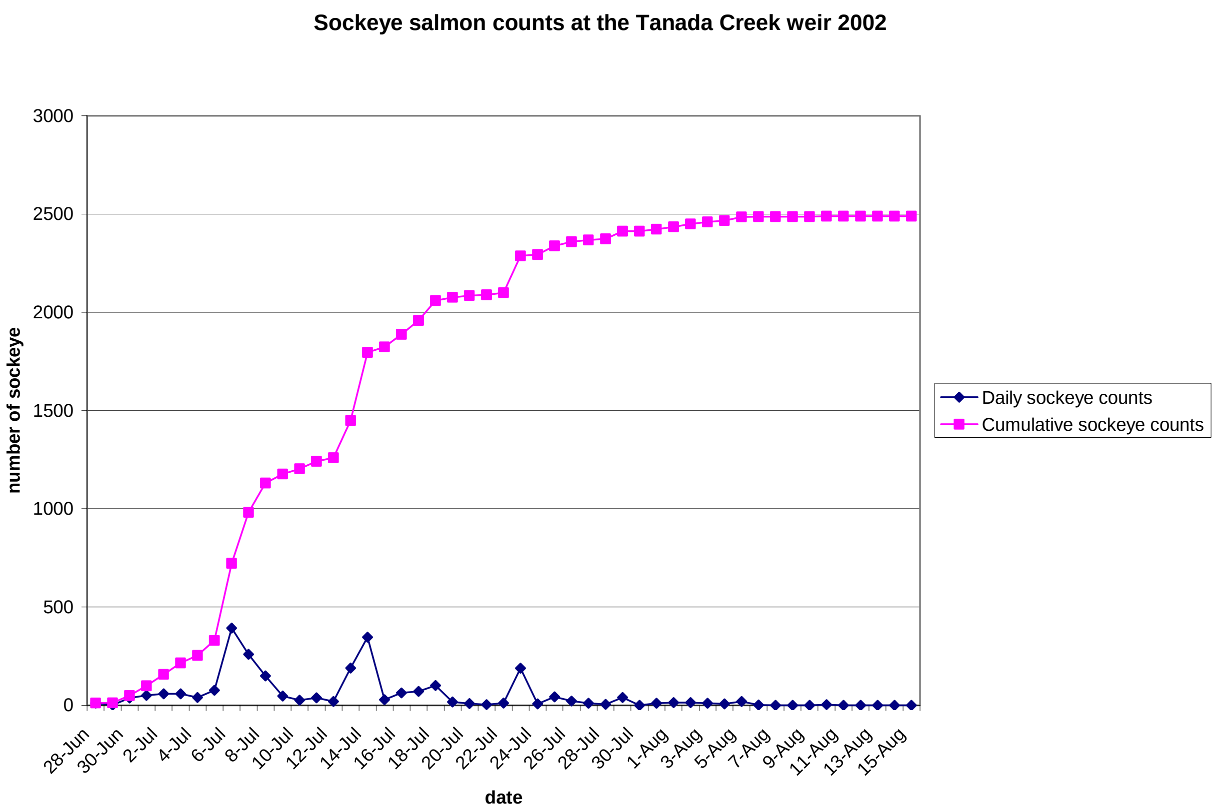

Figure 6. Cumulative and daily counts of sockeye salmon observations at the Tanada Creek weir.

Recapture history	Sample size
Weir only (1,0,0)	659
Marked weir, recapture event (0,1,0)	32
Recapture event one only (0,1,0)	215
Marked weir, recapture event 1 and 2 (1,1,1)	3
Marked weir, recapture event 2 (1,0,1)	23
Recapture event 1 and event 2 (0,1,1)	45
Recapture event 2 only (0,0,1)	384

Table 5. Recapture history and sample size.

Run Timing

The first sockeye salmon was observed at the weir June 28. The median point in the run occurred July 12 (Table 6).

Aerial Observations

Aerial surveys of Tanada Lake and the Tanada Lake outlet by ADF&G September 23, 2002 observed 1750 live and 200 dead sockeye in both the lake and the outlet for at total of 1950 salmon. This estimate is approximately 39 percent of the mark and recapture estimate of the total population. The relationship between aerial survey estimates and weir estimates are displayed in Figure 7. The trend in aerial survey estimates is displayed in Figure 8.

Capacity Building

On June 26, 2002, WRST was invited to present at the Batzulnetas culture camp held at the village site on Tanada Creek. The fisheries program sponsored a half day of fisheries related activities by providing staff facilitated activities and tours and purchasing supplies for fishery related art projects. Over twenty young people and many adults participated and shared in the experience. The weir was staffed by five local residents of Slana, a community located approximately 16 km northwest of the weir site.

	First fish	Median date	Median Number
1975	28-Jun	7-Jul	75
1978	8-Jul	28-Jul	1132
1979	25-Jun	22-Jul	5123
1997	23-Jun	4-Jul	13761
1998	13-Jul	19-Jul	14496
2001	14-Jun	14-Jul	825
2002	28-Jun	12-Jul	1245

Table 6. Annual dates of arrival of the first sockeye salmon at the weir and the median point of the sockeye salmon migration past the weir.

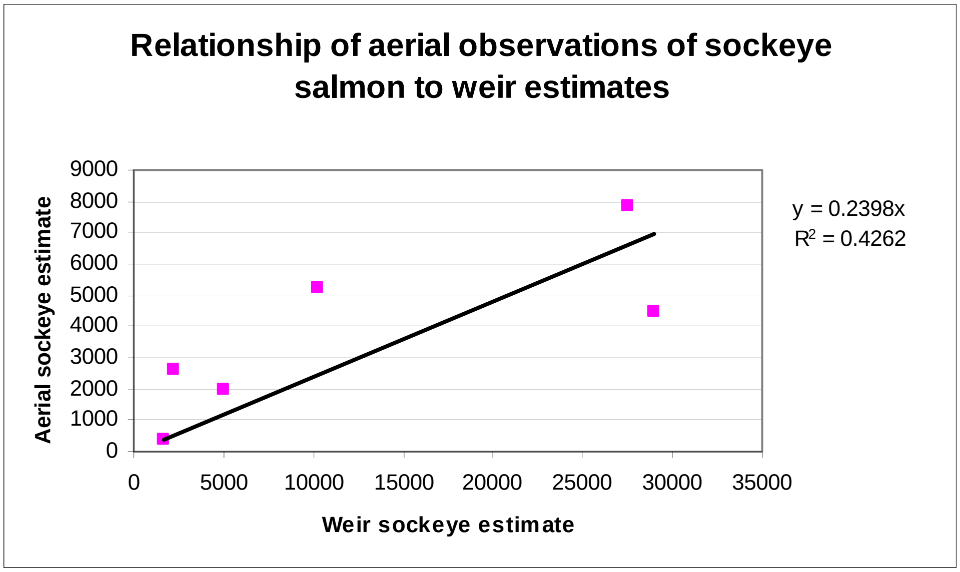

Figure 7. Relationship between aerial estimates and weir estimates.

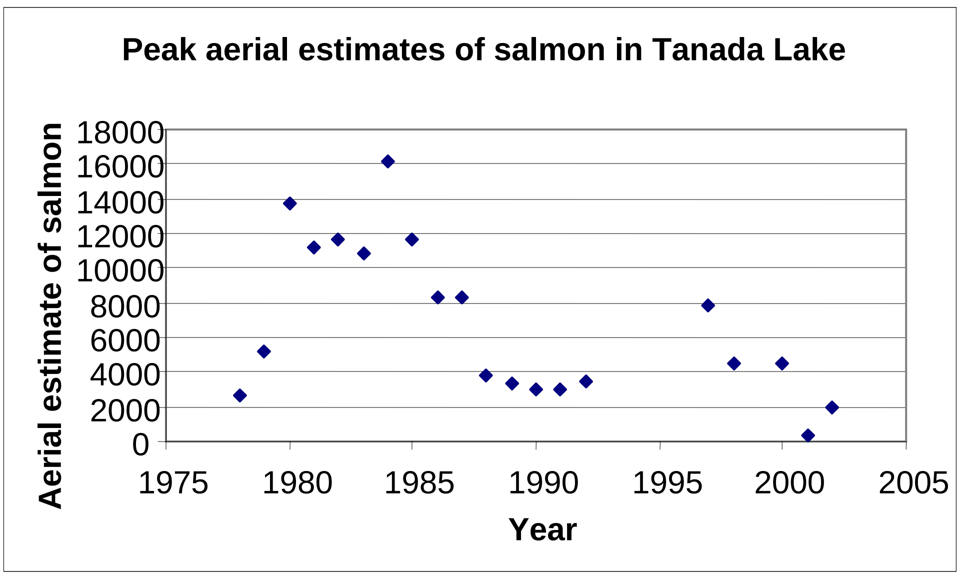

Figure 8. Trend of aerial observations of sockeye salmon in Tanada Lake and the lake outlet.

Video Escapement Estimation

The tower was erected and functioning while the weir was in operation. One problem we found after beginning to review the tapes is that the placement of the video tower downstream of the weir resulted in a high level of milling underneath the cameras that makes counting the fish difficult. Through July 13 4796 salmon were estimated to have passed through the video counting tower. The weir estimated 1449 salmon had passed by this date. The remainder of the tapes were not counted because the milling underneath the video cameras made accurate enumeration impossible.

DISCUSSION

Weir Operation

The floating resistance board weir outperformed the rigid picket weir that was used on Tanada Creek in 1997, 1998, and 2000. Although flood flows did occur in 2002, the weir was inoperative only one day. However, high flows in late May and early June did limit our ability to install the weir as early as desired. The late installation likely resulted in substantial fish leakage prior to installation of the weir. While the sand bags used to block the gap between the substrate rail and the base of the weir panels appeared to prevent fish leakage some fish leakage may have occurred. Snow and ice on the trail and stream banks prohibited installing the weir prior to the high flow period. Neither water temperature or staff height appeared to strongly influence migration.

Biological Data

The adult sockeye salmon population returning to Tanada Creek, estimated at 6186, appears to have been substantially higher than the population returning in 2001 but remains substantially lower than the populations that returned in 1997 and 1998. Figure 8 suggests a downward trend in the Tanada Lake sockeye salmon population.

The majority of the returning adults were 5 year-old fish having spent two years in freshwater and 3 years in salt water.

Post-season analysis of commercial harvest and escapement at Miles Lake indicated a good return of sockeye salmon throughout the Copper River Basin (ADF&G). Based on the 22-year average of 595,779 sockeye salmon, escapement in 2002 (819,886) was about 40% higher than average.

Historically, local indigenous Alaskans harvested salmon with spears, weirs and woven dip nets. Fish wheels were introduced into the Copper Basin around 1910 (Reckord 1983). Euro-Americans began commercial fishing activities in the Gulf of Alaska near the mouth of the Copper River in 1889. A number of area residents who are descendants of earlier inhabitants still utilize its resources for cultural education purposes including subsistence fishing which utilizes spear, dipnet, rod and reel in the creek, and fishwheels at the mouth (Table 4). The harvest in the Batzulnetas fishery in 2002 was the highest recorded since 1998.

Year	Permits Issued	Sockeye Harvest	Year	Permits Issued	Sockeye Harvest
1987	8	22	***1995***	4	16
1988	0	0	***1996***	0	0
1989	0	0	***1997***	1	428
1990	0	0	***1998***	3	582
1991	0	0	***1999***	1	55
1992	0	0	***2000***	0	0
1993	1	160	***2001***	1	62
1994	4	997	***2002***	1	208

Table 7. Participation and harvest of Batzulnetas fishery, 1987 – 2001

Run timing

Table 6 shows that the date of the first salmon observed at the weir ranges from June 14 to July 13. The median point of the run has ranged from July 4 to July 28. In 2002 both the date of the first salmon observed at the weir and the median run point fall approximately in the middle of the range for each of these values.

Aerial Observations

The relation between aerial survey peak counts and the population estimate obtained by operating the weir demonstrates an R^2 value of 0.43. Although this R-value may not defensibly suggest a strong correlation, the peak aerial counts on average represent 24 percent of the weir estimate, which is similar to values reported by other observers.

Capacity Building

During the educational program prepared for the participants of the Batzulnetas culture camp, WRST provided a forum for community members to observe the weir project in operation and ask questions about the abundance, timing and management of the Tanada Creek run. Five local residents of the Slana area were employed by WRST to staff the weir. Through this employment, they gained experience in monitoring, sampling, problem solving, and collecting, reporting and entering data.

Video Escapement Estimation

Video monitoring appears to be a potentially useful tool to estimate escapement in Tanada Creek. However, in 2002 we made a mistake by placing the video cameras slightly downstream of the weir which resulted in milling of salmon underneath the cameras. This appears to have resulted in a passage estimate that is biased high since the passage estimate using the cameras was 4796 prior to 7/13 while only 1449 sockeye were observed at the weir. While we believe some fish leakage occurred, based upon the mark and recapture estimate of 6186 we believe it is unlikely that the weir leaked 3347 salmon during this period. The tapes for the remainder of the season had a high level of milling and were not feasible to count. We plan to relocate the counting tower in 2003 to avoid the milling.

CONCLUSIONS

Weir Operation

A floating resistance board weir was an appropriate design for the dynamic Tanada Creek system. Although high flows did delay installing the weir, the weir performed well once installed, requiring only minimal maintenance to continue operating.

Biological Data

The 2002 population estimate for sockeye in Tanada Creek is within the historic range of estimated escapements. The 2002 return of slightly more than 6000 salmon supported the highest harvest in the Batzulnetas fishery since 1998, which was considered a record high return. Neither the age composition nor the run timing appear substantially different from previous years. Aerial survey peak counts and weir estimates do not yet show a strong correlation, however in the absence of weir data we believe these counts provide a useful index of escapement. Based upon the peak counts we believe the sockeye population in Tanada Lake is displaying a downward trend.

RECOMMENDATIONS

Biological Data

1. Incorporate limnology sampling of Tanada Lake with the objective of estimating lake productivity and obtaining a preliminary estimate spawning escapement.

2. Investigate smolt outmigration in Tanada Lake to determine outmigration timing, to collect biological information, and to apply coded wire tags to determine recovery rate of Tanada Creek sockeye in the commercial and subsistence fisheries of the Copper River.

Video Escapement Operation

1. Continue for at least one more year with the video escapement to establish if the counts from the video tapes are as reliable and accurate as the weir counts.
2. Relocate the video counting tower upstream of the weir in fast water to avoid the “milling” caused by the weir upstream of the tower.

Management

1. Continue monitoring to work towards defining what natural and healthy sockeye escapement is for Tanada Creek stocks.
2. Collect additional weir data to more accurately assess the trend in population abundance. While the aerial counts suggest a downward trend, additional weir data is likely to more accurately assess this trend.

ACKNOWLEDGEMENTS

The National Park Service would like to thank the Village of Mentasta Lake, Katy John and Doris Charles for allowing use of their land for the purpose of conducting this project. The U.S. Fish and Wildlife Service, Office of Subsistence Management, provided $44,500 in FY02 in funding support for this project through the Fisheries Resource Monitoring Program, under agreement number FIS00-01-3.

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Appendix A. Tanada Creek daily salmon counts 2002

	Sockeye Count		Chinook Count	
Date	Daily	Cumulative	Daily	Cumulative
28-Jun	11	11		
29-Jun	1	12		0
30-Jun	37	49		0
1-Jul	50	99		0
2-Jul	58	157		0
3-Jul	58	215		0
4-Jul	39	254	2	2
5-Jul	76	330	2	4
6-Jul	392	722		4
7-Jul	259	981		4
8-Jul	149	1130	1	5
9-Jul	47	1177		5
10-Jul	26	1203		5
11-Jul	38	1241		5
12-Jul	19	1260		5
13-Jul	189	1449		5
14-Jul	347	1796		5
15-Jul	28	1824		5
16-Jul	63	1887		5
17-Jul	71	1958		5
18-Jul	101	2059		5
19-Jul	17	2076		5
20-Jul	9	2085		5
21-Jul	3	2088		5
22-Jul	11	2099		5
23-Jul	188	2287		5
24-Jul	7	2294		5
25-Jul	43	2337		5
26-Jul	21	2358		5
27-Jul	10	2368		5
28-Jul	5	2373		5
29-Jul	39	2412		5
30-Jul	0	2412		5
31-Jul	10	2422		5
1-Aug	13	2435		5
2-Aug	14	2449		5
3-Aug	10	2459		5
4-Aug	7	2466		5

5-Aug	19	2485		5
6-Aug	1	2486		5
7-Aug	0	2486		5
8-Aug	0	2486		5
9-Aug	0	2486		5
10-Aug	3	2489		5
11-Aug	0	2489		5
12-Aug	0	2489		5
13-Aug	0	2489		5
14-Aug	0	2489		5
15-Aug	0	2489		5
16-Aug		2489		5
17-Aug		2489		5
18-Aug		2489		5
19-Aug		2489		5
20-Aug		2489		5
21-Aug		2489		5
22-Aug		2489		5
23-Aug		2489		5

Appendix B. Schnabel Modeling and Analysis for Mark and Recapture Events

03/23/04

From: Karen Hyer
FIS, OSM
907-786-3689

To: Eric Veach
Wrangell-St. Elias National Park/Preserve

This memo is a follow-up to our phone conversation and contains the analysis details of Tanada Creek sockeye salmon data. If you have any questions please feel free to call me.

Since event one and two were completed on consecutive days and event three and four were completed on consecutive days, I combined consecutive days into one recapture event. This simplified the analysis and increased the sample size. Given that each recapture event occurred over a relatively short time period (48 hours) the assumption of a stable system is reasonable. In addition, Fisher (1973) states that even if closure is approximate the Schnabel model still produces an accurate estimate. Combining events resulted in following is sample size

Recapture history	sample size
Weir only (1,0,0)	659
Marked weir, recapture event 1 (1,1,0)	32
Recapture event 1 only (0,1,0)	215
Marked weir, recapture event 1 and 2 (1,1,1)	3
Marked weir, recapture event 2 (1,0,1)	23
Recapture event 1 and event 2 (0,1,1)	45
Recapture event 2 only (0,0,1)	384

There were 54 multiple recaptures in recapture event 1 and 82 multiple recaptures in recapture event 2. Multiple recaptures were not included in the analysis.

In addition to calculating the model with combining events, I calculated a model dropping event 2 and event 4. Comparing the two models gives an estimate of precision gained by sampling over a 48 hours verse 24 hours.

Model	Abundance Estimate	S.E.	95% C.I.
48 hours	6186	537	5243-7358
24 hours	7074	968	5456-9287

Dropping event two and event four increased the standard error by a factor of 1.8. Given this increase, I would recommend continuing the 48 hour sampling.

Below is draft text which may be used in the report. The following text contains no formula for the Schnabel estimator because MARK uses maximum likelihood methods to produce the estimate. This method of estimation does not lend itself to closed form formulas. The program MARK is well documented so I feel referring the reader to the analysis technique is sufficient.

Draft Report Text

Analysis

Recaptures from the first two sampling events were pooled to calculate the first recapture event. If a salmon was recaptured more than once during the two-day event, additional recaptures were noted on the datasheet but were not used in the abundance calculation. Recaptures from the third and fourth sampling event were pooled to calculate the second recapture event. Again, salmon recaptured more than once during the second two-day event were noted on the datasheet, but additional recaptures were not used in the abundance estimate.

Abundance of sockeye salmon was estimated using the mark and two-event recapture histories of fish according to the Schnabel model. The Schnabel model allows for time variation in capture probabilities. The assumptions necessary for a reliable estimation of abundance are:

1. all salmon have a constant probability of capture within a sampling event;
2. the population remains constant with no recruitment and mortality during the sampling event; and,
3. marked fish do not lose their marks.

Assumption one was tested by fitting two models. First, a model assuming heterogeneous capture probabilities within a sampling event was fit to the data. A second model assuming constant capture probabilities was then fit to the data. The most parsimonious model was chosen as the correct model. To meet the second assumption recapture sampling was started 13 days after the last salmon was marked at the weir. The 13 day time period allow all the fish to migrate into the lake. Finally, batch marks were given to the fish eliminating the need for external tags and potential for tag loss. The majority of fish sampled (93%) were alive, and marks did not deteriorate as they might on decomposed carcasses.

The computer program MARK was used to generate the estimate.

Results

The estimate of the total sockeye salmon in Tanada Lake using mark-recapture techniques was 6,186 (95% CI=5243, 7358; SE=537).

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